Industrial Base Modeling for Space Launch Propulsion Acquisition

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Overview

- Propulsion system acquisition status
- Industrial base composition and health
- Additive manufacturing compared to traditional manufacturing
- Supply chain & workforce modeling
- DoD & NASA public-private partnerships

Propulsion System

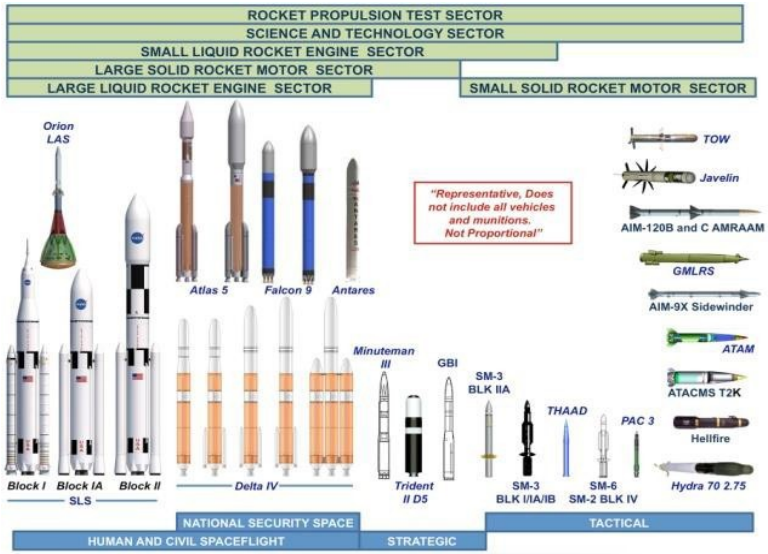
A photo released by SpaceX Jan. 3 shows the Falcon 9 first stage that landed Dec. 21 in the company's hangar near Launch Complex 39A at NASA's Kennedy Space Center. Credit: SpaceX

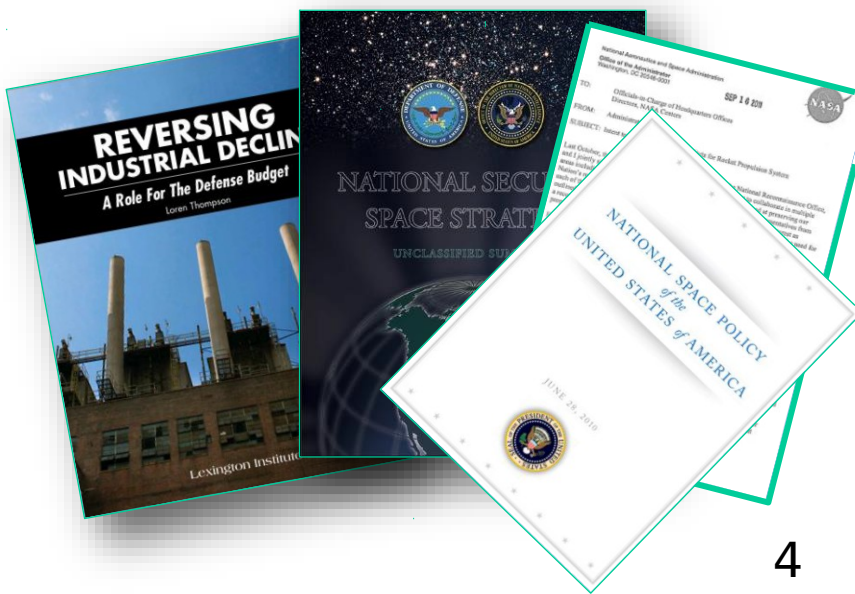
A 1/6 scale model of the AR1 engine currently in development by Aerojet Rocketdyne as a replacement for the Russian-built RD-180 engine that powers United Launch Alliance's Atlas 5 rocket. Credit: Aerojet Rocketdyne

RD-180 engine. Credit: NPO Energomash

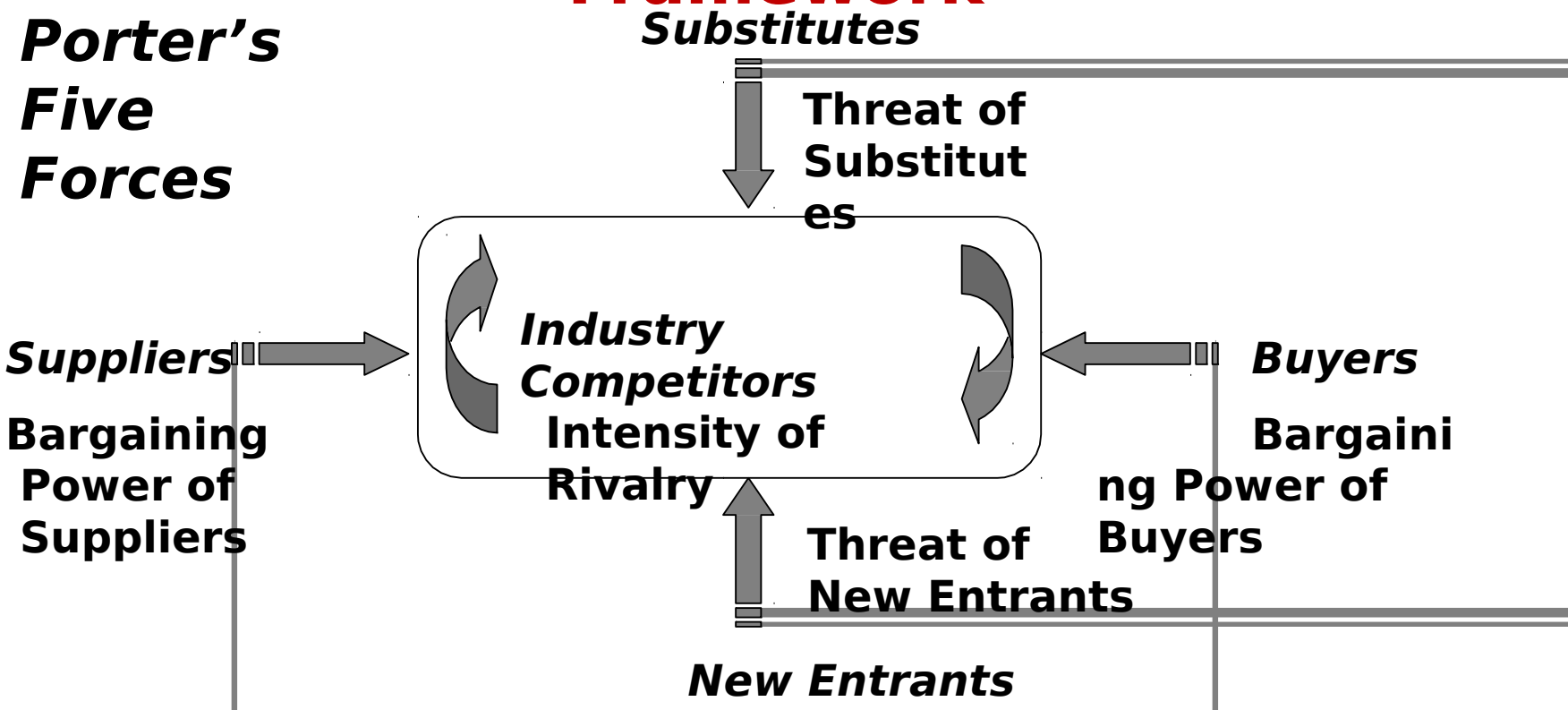
Propulsion Industrial Base is a National Concern

- Congressional and Executive Office concerns about Rocket Propulsion Industrial Base (RPIB)
  - Widespread recognition of the problem
  - Sustainment of the solid rocket motor and liquid rocket engine industrial base is a national challenge that spans multiple departments and agencies of the U.S. Government.
  - Integrated approach among the leadership of US Government Agencies
  - Need for accurate analysis and data to inform decision makers across USG Agencies
- What is NIRPS? National Institute for Rocket Propulsion Systems
- Started on September 16, 2011 through authorization letter signed by NASA Administrator Charlie Bolden to work together with USAF and NRO to address
  - Resource light but "results





Industrial Base Health Framework



- Five key categories of forces as threats to competitive advantage.
- Clear representation of external and internal forces.

Industrial Sector of Interest

NAICS 336414 Guided Missile and Space Vehicle Manufacturing

This U.S. industry comprises establishments primarily engaged in:
(1) manufacturing complete guided missiles and space vehicles and/or (2) developing and making prototypes of guided missile or space vehicles.

This Industry is comprised of:

- Developing and producing prototypes for complete guided missiles and space vehicles
- Guided missile and space vehicle manufacturing
- Guided missiles, complete, assembling
- Rockets (guided missiles), space and military, complete, manufacturing
- Space vehicles, complete, manufacturing

Source: www.siccode.c

Competitive Threat Definitions/Assessment

•Threat of New Entrants: HIGH barriers to entry due to intensive capital investment, need for economies of scale, strict regulation, research and development investment, and contract based sales with government entities. Dual use of commercial products within government and industry could shift bias lower.

•Threat of Substitutes: LOW due to limited number of producers and customized product choices, with most products being order-specific. Switching costs are also high, but price- performance tradeoff of substitutes could present opportunities.

•Bargaining Power of Suppliers: HIGH-MED due to advanced technology used in parts, long lead times for production, and contracts used for sales. Also, few producers in the market with different product lines serving different needs. Foreign suppliers and US Government influences in the manufacturing process could reduce this threat.

•Bargaining Power of Buyers: MED-LOW due to many airlines purchasing aircraft and few qualified producers. However, negotiations on price exist for large buyers, bids for government contracts, emergence of non-US suppliers.

•Intensity of Rivalry: MED primarily due to tempering influences of high concentration ratio, long-term contracts, sustainable market growth, and significant brand identification/differentiation. Some upward bias given high strategic stakes and high exit barriers. Some niche market US participants and

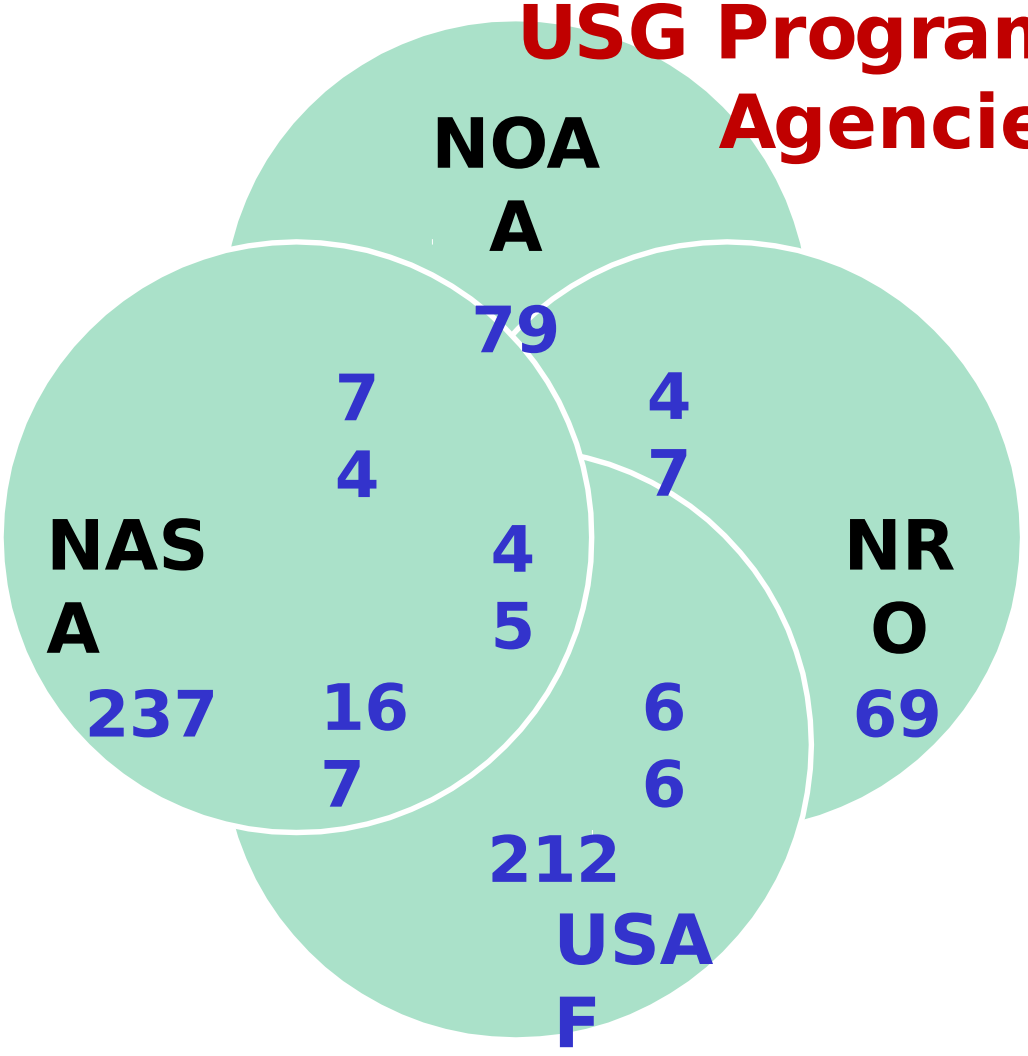
Source: http://www.hoovers.com/industry-facts.aerospace-products-parts-manufacturing.1021.html

Propulsion Survey Assessment Background

- Partnership between Department of Commerce (DoC) and NIRPS
- *The principle goal is to gain an understanding of the supply chain network supporting the development, production, and sustainment of products and services supporting both US Government (USG) and commercial propulsion-related systems.*
- Objectives:
  a) Map the propulsion industrial base supply chain in unprecedented detail;
  b) Identify interdependencies between respondents, suppliers, customers, and USG agencies;
  c) Benchmark trends in business practices, competitiveness issues, financial health, etc. across many tiers of the propulsion industrial base; and
  d) Share data with USG stakeholders to aid planning, outreach, and

Source: U.S. Department of Commerce, Bureau of Industry and Security
Advanced Propulsion Survey Public Release

RPIB Risks Are Shared Across USG Programs and Agencies



354 respondents were determined to be financially high/severe risk*

Sample of four USG agencies and their shared supplier risk

Cross-cutting relationships can be viewed by product or program

* Based on a series of financial risk measures, taking into account profitability, liquidity, leverage, and others

Source: U.S. Department of Commerce, Bureau of Industry and Security, Office of Technology Evaluation

NIRPS/DoC RPIB Survey

- Shared risk between agencies and programs
  - Need to understand risk
  - Need to to identify “at-risk” suppliers and any potential
    Risk mitigation
  - Need to follow trends in the RPIB to gauge effects of foreign competition, new entrants and advanced manufacturing technologies
- Data will be used to inform decisions
  - Update supply chain model with current data
  - Shared with other government agencis and

NIRPS/DoC RPIB Survey

- **January-April 2016**
  - Survey design, mailing list cleanup, site visits, and field testing
- **May 2016**
  - OMB Approval Process
- **June-August 2016**
  - Survey distribution, 1st and 2nd waves
- **September-October 2016**
  - Survey return/compliance/quality control procedures/database build
- **November-December 2016**
  - Preliminary briefings and distribution of full dataset to NASA/MSFC

Additive Manufacturing Can Be A Transformational Technology

- Additive Manufacturing (AM) is an emerging technology that requires a public/private partnership to optimize the use of this technology
- Areas of partnership include
  - Materials Characterization
  - Process Modeling
  - Standards and requirements
- AM will have a significant impact on the Propulsion
  Industrial Base (needs to be quantified)

Additive Manufacturing Can Be A Transformational Technology (cont'd)

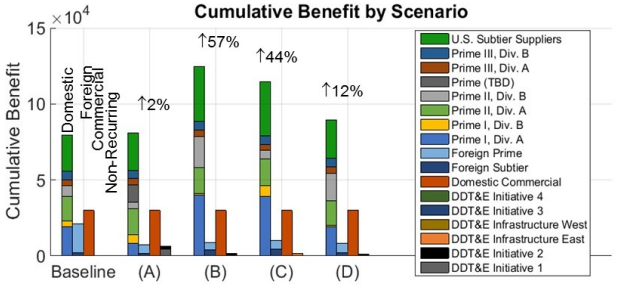
- Allows rapid prototyping of potential designs for multiple design, test, fix cycles
- Complex designs not feasible by conventional subtractive manufacturing can be fabricated and may contribute to performance optimization
- Provides an alternative method of production, when traditional suppliers are not available or do not have production

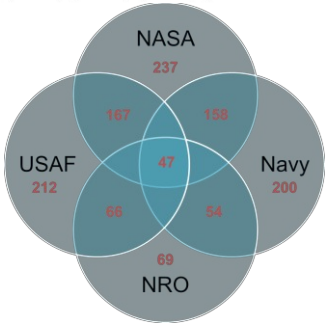
Additive Manufacturing

- Placeholder for Rajiv -

Rocket Propulsion Industrial Base Evaluation

- **Develop capability to perform propulsion supply chain analysis to inform decision makers**
  - Initiated Aerospace Corp. task in 2013 to generate multi-layer propulsion supply chain maps for Space Launch System (SLS) and develop methodology to identify connectivity between suppliers and identify risks/obsolescence issues
    - Resulted in development of a hybrid Supply Chain Database with Probabilistic Scenario Analysis, Propulsion Supplier Integrated Modeling and Analysis (PropSIMA)
    - Now includes over 600 propulsion-related suppliers across multiple USG and Commercial programs and vehicle, engine, motor demand models to 2030
  - Performed analysis for SLS program on Exploration Upper Stage (EUS) options
    - Hydrogen (LH2) Booster Engine risk reduction efforts and IP impacts
  - Supporting USAF Evolved Expendable Launch Vehicle (EELV) Procurement and Acquisition Strategies
    - IP impacts due to New Commercial Entrants
    - Using integrated DoD, NASA and Commercial LV



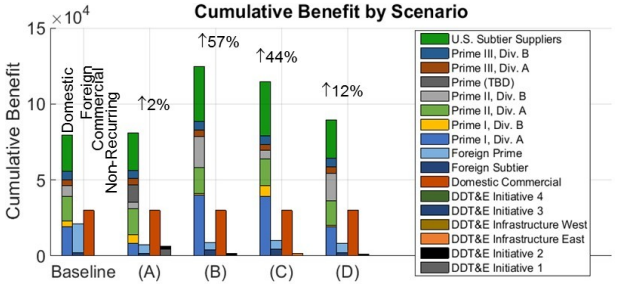


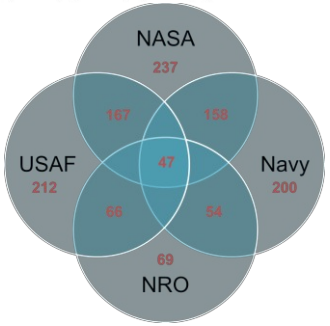
Shared Suppliers (ref 2013 Deep Dive)

Rocket Propulsion Industrial Base Evaluation (cont'd)

- Developing Propulsion Skills/Capabilities scenario analysis to help understand NASA's skill mix risks
- Collaborating with the Department of Commerce to develop and trend RPIB metrics and critical supplier pedigrees
  - Focused survey will be issued to approximately 200 critical suppliers mid-2016
  - Inquiry topics will include Financials, R&D, Employment, Sales and Key Suppliers/Customers/Competitors
  - Integrated approach with JANNAF* PIB to assess shared USG trends and risks

* JANNAF – Joint Army Navy NASA Propulsion Subcommittee





Shared Suppliers (ref 2013 Deep Dive)

DoD & NASA Public-Private Partnerships

National Space Transportation Policy* (Two Distinct Launch Agents)

•"Administrator, NASA, as the launch agent for civil space missions, shall:
–Develop, in support of US space exploration goals, the transportation-related capabilities necessary to support human and robotic exploration to multiple destinations beyond low-Earth
orbit, including an asteroid and Mars"

•"Secretary of Defense, as the launch agent for national security space missions, shall:
-Ensure, to the maximum extent possible, the availability of at least two US space transportation vehicle families capable of reliably launching national security payloads"

•"Secretary of Defense and Administrator, NASA, shall:
–Assure access to space for USG departments and agencies taking into account risk management, affordability, competition among providers, and measures for enhancing transparency regarding USG space transportation needs
–Rely on US-manufactured capabilities and services, and ensure the ability to develop, operate,
and enhance space-transportation capabilities, infrastructure, and support alternatives"
–Work with each other and other departments and agencies, and with the private

* November 21,

Additional Model Uses

- Placeholder if needed for PropSIMA -

Availability Of Model

- Placeholder if needed for PropSIMA -

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